Ultrasonic Fuel Regression Measurement in Hybrid Rocket Motors

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A technique for utilizing ultrasonic transducers to measure hybrid motor fuel regression rates during motor operation was developed and demonstrated on the Large Subscale Solid Rocket Combustion Simulator Program. This technique consisted of installing specially developed ultrasonic transducers into solid rocket combustion simulator motor cases (11 and 24 inches in diameter) configured with a specially formulated hybrid fuel designed to simulate a solid rocket motor exhaust environment.

The transducers, developed by MSFC and contractors Lockheed Martin Astronautics and Thiokol Space Operations, consisted of dual-pitch/catch units installed in a single stainless-steel housing (fig. 49). The transducers were installed along the length of the motors and successfully measured fuel regression during motor operation by sending ultrasonic signals through the fuel and recording the time it takes for the signal to return to the unit (fig. 50): thus, the terminology "pitch/catch"—one unit pitches the signal, the other catches it. Running controlled samples in the laboratory and on the motors prior to firing allowed the team to establish a known factor for the densities of the fuel and case materials. This factor represents the time for the ultrasonic pulse to travel through a given thickness of fuel and back again. During motor operation, as the fuel regresses (burns back), the thickness changes, thereby measuring the time it takes for the signal to travel back and forth. The transducer sends signals continuously during motor operation, and—with the aid of a personal computer—graphical interpretations are generated to represent grain regression (fig. 51).

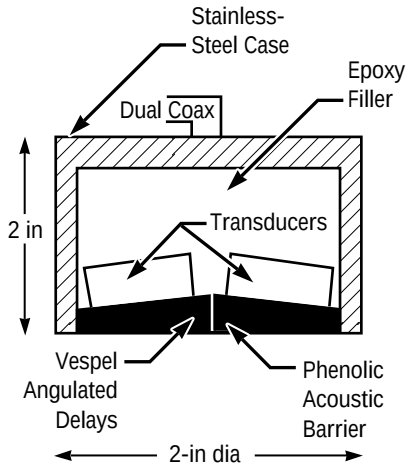

FIGURE 49.—Ultrasonic transducer.

Posttest measurements verified the accuracy of the system within 0.002 inch of physical measurements. The incorporation of such an ultrasonic measurement system in future hybrid and solid motor testing will allow substantial cost and time savings over the traditional methods of disassembling motors and performing physical measurements in a number of locations. In addition, ultrasonic fuel regression measurements made in real time during a motor firing allow scientists and engineers to adjust hybrid oxidizer flow rates in real time to obtain steady oxidizer flux rates, if needed, for enhanced solid rocket motor simulation.

The techniques developed and proven on the Solid Propulsion Integrity Program will be used to measure fuel regression rates on motors ranging from 11 to 70 inches in diameter during the Hybrid Propulsion Demonstration Program, beginning in late 1995. The Hybrid Propulsion Demonstration Program is a consortium of industry and government participants utilizing a combination of private and public funding to further develop hybrid propulsion technology. This program will culminate in the test-firing of space booster-sized motors (producing 250,000 pounds of thrust) at MSFC. The real-time measurement of fuel regression during static tests by way of ultrasonic measurements is an integral portion of this important new propulsion technology development.

Boardman, T.A.; Porter, L.G.; Brasfield, F.W.; and Abel, T.M. July 1995. An Ultrasonic Fuel Regression Rate Measurement Technique for Mixture Ratio Control of a Hybrid Motor. Paper 95–3081, 31st American Institute of Aeronautics and Astronautics/ American Society of Mechanical Engineers/Society of Automotive Engineers/American Society of Electrical Engineers Joint Propulsion Conference and Exhibit.

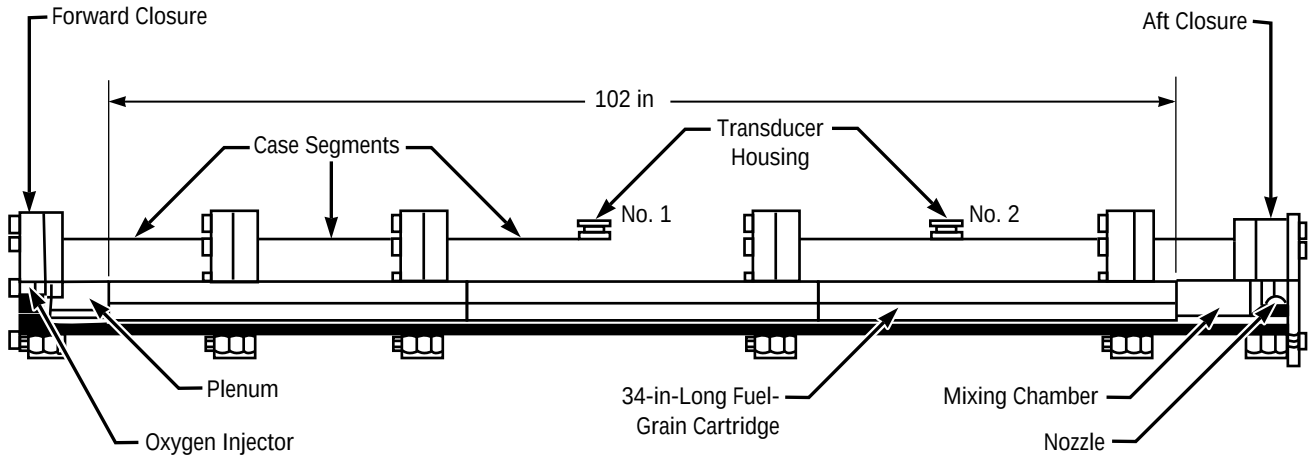

FIGURE 50.—11-inch motor configuration.

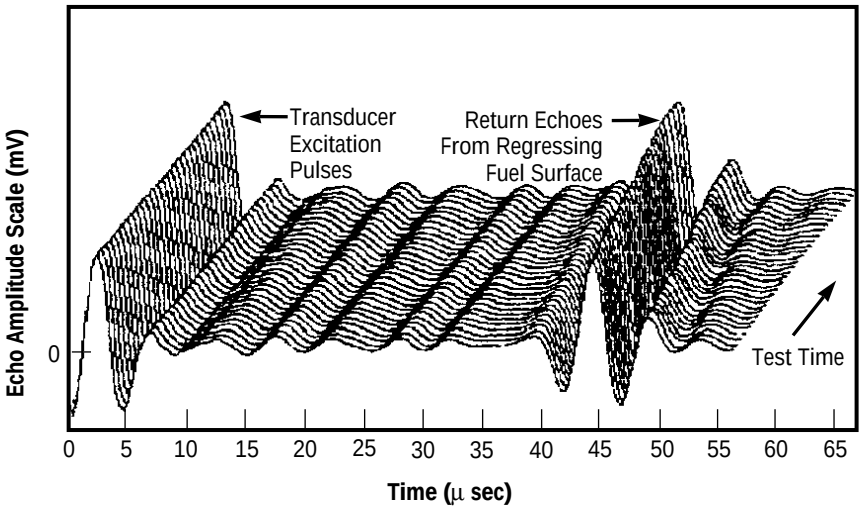

FIGURE 51.—Graphic representation of grain regression measurement.

Sponsor: Office of Space Access and Technology

Industry Involvement: Lockheed Martin Astronautics, Thiokol Space Operations, and Ultran Laboratories

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